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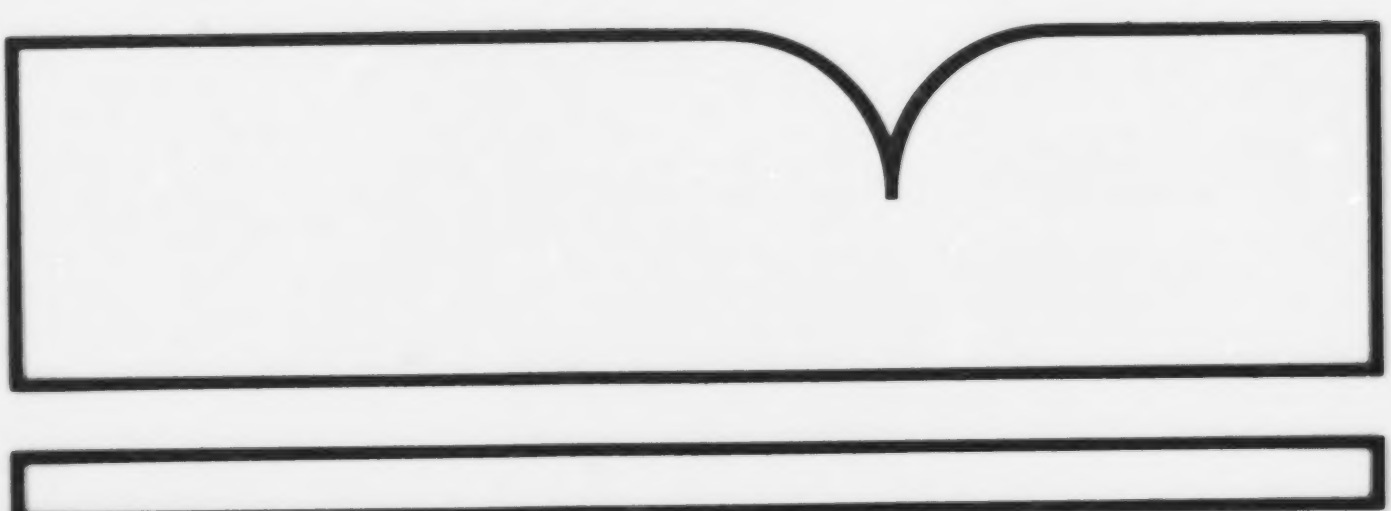

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16. ABSTRACT

A continuing program has been conducted since 1970 to determine levels of radioactive nuclides in adults and children from families residing in communities and ranches surrounding the Nevada Test Site. Twice each year these persons receive a whole-body count and physical examination; a urine sample from each is also submitted for radionuclide analyses. The only fission-product radionuclide routinely found in whole-body counting has been ^{137}Cs concentrations similar to those in persons living in other areas of the United States. The physical examinations reveal a generally healthy population, and urine samples have shown no remarkable radionuclide content.

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RESULTS OF A SURVEILLANCE PROGRAM FOR PERSONS LIVING AROUND THE NEVADA TEST SITE— 1971 TO 1980*

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Abstract—A continuing program has been conducted since 1970 to determine levels of radioactive nuclides in adults and children from families residing in communities and ranches surrounding the Nevada Test Site. Twice each year these persons receive a whole-body count and physical examination; a urine sample from each is also submitted for radionuclide analyses. The only fission-product radionuclide routinely found in whole-body counting has been ^{137}Cs at concentrations similar to those in persons living in other areas of the United States. The physical examinations reveal a generally healthy population, and urine samples have shown no remarkable radionuclide content.

INTRODUCTION

A PROGRAM WAS initiated in December 1970 to determine levels of radioactive nuclides in a population consisting of persons from families residing in communities and ranches surrounding the Nevada Test Site.

This report is based on data taken by the Environmental Monitoring Systems Laboratory (EMSL-LV) over a 10-year period from December 1970 to July 1980. This continuing effort is titled the Off-Site Human Surveillance Program. The objectives are—

(1) Determine the current health status and levels of radionuclides in off-site residents.

(2) Determine whether any observed body burdens of radionuclides might be related to known deposition patterns from past nuclear tests.

(3) Establish a control population group which can be surveyed in the event of a future release of radioactive material from the Nevada Test Site.

*Prepared under U.S. Department of Energy Memorandum of Understanding No. DE-AI08-76DP00539.

PROCEDURES

Forty-one families comprising 175 individuals have been included in the program. The geographical locations of the participating families are shown in Figs. 1 and 2. Figure 1 shows the Nevada Test Site location in relation to roads and towns. Figure 2 has the majority of these features removed in order to show the residence locations for the families in the Off-Site Human Surveillance Program. The line across Fig. 2 was arbitrarily drawn to divide the families into north and south sectors. Since prevailing winds at the Nevada Test Site are toward the north or northeast, a difference in exposure may exist for these two sectors. In addition, fallout from major NTS releases principally involved persons in the north group. Sixty-two per cent of the persons are in the north sector.

Since 1962, all nuclear weapons tests have been conducted underground. None of the tests since then, including the Baneberry test that vented in 1970, has produced radioactivity off-site that exceeded radiation safety guidelines (US81). Some of the PLOWSHARE cratering experiments, the

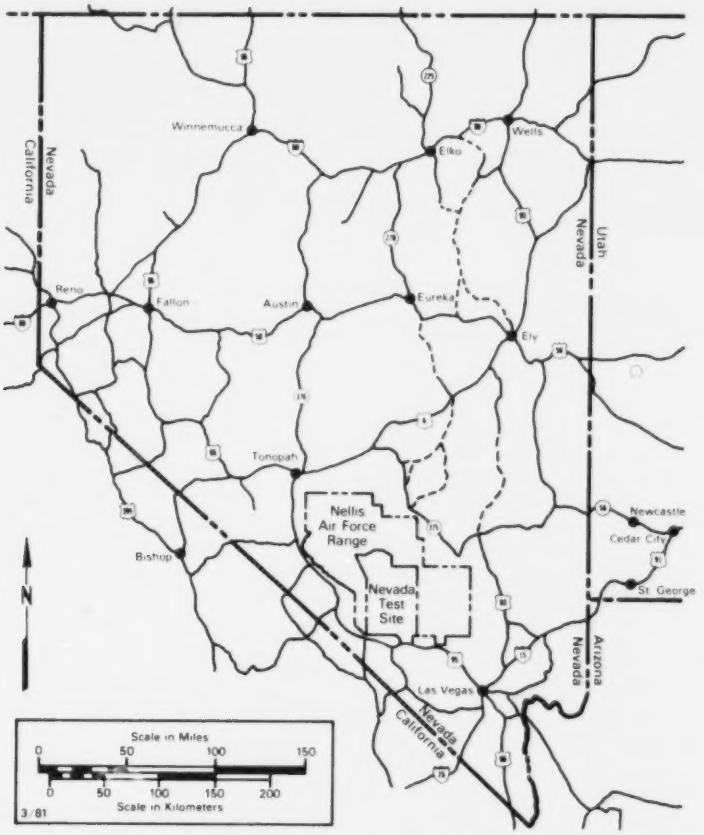

FIG. 1. Location of the Nevada Test Site.

last event being Schooner in 1968, released radioactivity readily detectable in persons off the test site (NT68, Ec72). The short lived radioisotopes from Schooner and earlier tests had decayed to non-detectable levels long before the Offsite Human Surveillance Program was initiated.

Families representing the selected off-site areas were contacted by environmental monitor personnel working for the Environmental Protection Agency. Families were selected primarily on the basis of the length of residence in the area, family size, and geographical location with respect to the Test Site. Willingness to participate in the program is the final determinant. Those selected travel each spring and fall to the Environmental Monitoring Systems Laboratory-Las Vegas, where a whole-body count of each person is performed to determine the body-burden of γ-emitting radionuclides. A urine sample is collected and analyzed for ^{239}Pu and ^{238}Pu, and for tritium. These nuclides cannot be detected with the whole-body counter. A short medical history, complete blood count, thyroid profile and physical examination are obtained for each participant. Payment for participation by the subjects is limited to transportation and living expenses while away from their residence. Results of the whole-

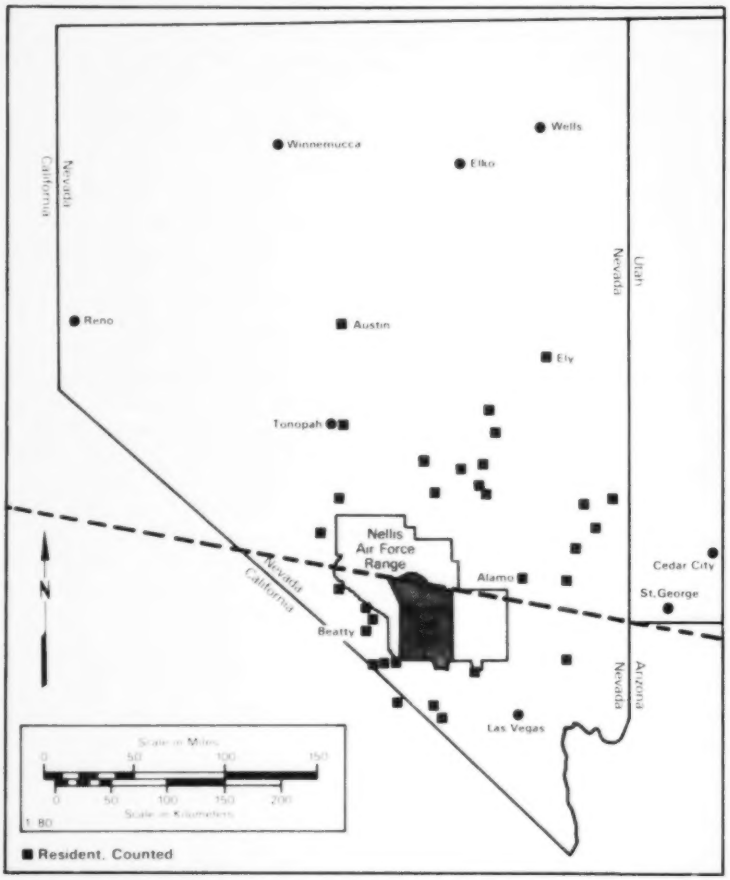

FIG. 2. Locations of residents participating in the Offsite Human Surveillance Program.

body count are available before the families leave the facility and are discussed with the subjects. The results of the blood and urine tests are sent to the families, along with a letter of explanation from the examining physician.

The whole-body counter data output allows identification and quantification of radionuclides which emit γ-rays between 0.1 and 2.4 MeV; these include radioisotopes such as ^{60}Co, ^{131}I and ^{137}Cs. A few radioisotopes, such as ^{90}Sr and ^{32}P, do not emit γ-rays and would not be detected by whole-body counting. Although urine samples were analyzed for only selected plutonium isotopes and tritium, analyses for other radionuclides would have been requested had other envirinmental monitoring programs (air, water, milk, soil, vegetation) conducted by EMSL-LV indicated they were present in the environment in sufficient quantities that they might be of significance in people.

The only fission product radionuclide routinely detectable in the subject population by whole-body counting was ^{137}Cs. The ^{137}Cs body burdens were measured in the Environmental Monitoring Systems Laboratory whole-body counter located at Las

Vegas, Nevada. The counter is described in the *Directory of Whole-Body Radioactivity Monitors*, (*IAEA*, 1970). The detector used is a 23 × 10 cm NaI(tl) crystal optically coupled to seven low-background, magnetically-shielded, photomultiplier tubes. The signal output from each photomultiplier tube is connected in parallel through a summing box with the combined output routed to a battery-operated preamplifier and then to a pulse height analyzer calibrated at 10 keV per channel.

Quality control test procedures are performed daily to insure linearity and reproducibility of results from the initial counts to current results. These tests include daily counting of radioactive standards and periodic specific calibrations through the use of phantoms. The phantoms are filled with known amounts (NBS Traceable) of radioactive material and are designed to simulate actual people. For example, the counting system was calibrated for measurement of ^{137}Cs and naturally occurring ^{40}K by constructing phantoms of 1 kg bags of commercial granulated sugar, with known amounts of ^{137}Cs added. Bags with reagent grade potassium chloride added were used to simulate normal amounts of naturally occuring ^{40}K in persons. Phantoms were assembled from the bags to resemble men, women and children of various heights and weights. Calibration curves were developed relating counting efficiency to the size of the phantom. The counts in the ^{137}Cs photopeak were integrated and the background and ^{40}K scatter contribution were subtracted. The ^{137}Cs body burdens were calculated using phantom data as standards.

In addition to summarizing ^{137}Cs data for all persons in the north and south sectors, data are summarized for age groups as follows:

1. Birth years 1961–1971
2. Birth years 1941–1960
3. Birth years 1931–1940
4. Birth years prior to 1931.

The first group was born after the major atmospheric tests by the United States and a few were infants during the USSR tests of 1961–1962. These persons were less than 10 yr old at the start of this program and make up 21% of the population counted.

Persons in the second group were infants to 19 yr old (major growing years) when the major atmospheric fallout occurred (10–30 yr old at start of counting). This group makes up 39% of the persons counted.

Ages in the third group ranged from 21 to 30 yr (major reproductive years) during the major atmospheric testing and 31–40 yr at the start of our measurement program. Persons in this group comprised 16% of the total.

Persons in the fourth group were older than 30 during major atmospheric testing and over 40 at the start of counting. This group made up 24% of the population counted.

These groups were arbitrarily selected to give a reasonable separation by age categories following the last period of major atmospheric testing (1961–1962) while maintaining a reasonable number of persons in each age category for both the north and south groups.

RESULTS AND DISCUSSION

Results of measurements of the 1971 to 1980 period are shown in Tables 1–4 and in Fig. 3. In Tables 1 and 2 are given yearly averages for ^{137}Cs concentrations in persons in the north and south sectors, as well as for the four age groups. Some information on the number of people examined is given in Tables 1 and 2; more detailed information is given in Table 3. For Table 1, the values less than 5 pCi/kg were excluded (the detection limit of the whole-body counter). For Table 2, the less than 5 pCi/kg values were included by assuming them to be an actual 5 pCi/kg. The differences in the resulting averages are about 2 pCi/kg lower when the less than 5 pCi/kg values are included. For personal reasons, most families could not come to be examined each spring and fall of every year, and all participating family members did not come in each time the family was examined. Table 4 was prepared to summarize data for those persons who were counted eleven or more times during the 10-yr period and did not miss being examined for more than one calendar year. The data for these 56 persons from 19

Table 1. Offsite human surveillance program whole-body counting results for ^{137}C mean values, ^{137}Cs in pCi/kg of body weight (all values <5 pCi/kg excluded)

For <5 Values Excluded	Number Families	Number Individuals	Number Counts	Mean pCi/kg for Year and Group Designated										Mean All Years	Maximum Value
				1971	1972	1973	1974	1975	1976	1977	1978	1979	1980		
1. All persons	41	175	939	27.5	21.5	17.5	16	16.5	14.5	16	15	16	15	17.7	75
North Group	27	110	605	29	23	19	14.5	17	14.5	15	14	16.5	14	17.8	75
South Group	14	65	334	22	16.5	16	17	16.5	14.5	17.5	16.5	14.5	18	16.9	70
Birth Year 1961-71	21	36	182	27.5	19.5	11	15	16	11	13	12	15	15	15.5	75
" " 1941-60	31	68	232	30	21.5	17	16	14	12.5	18.5	13	14	12	17.1	70
" " 1931-40	22	28	180	37.5	23.5	16	16	17.5	13	16	16	12	14	18.4	60
" Prior to 1931	27	43	345	29.5	23	22.5	15	17	16.5	18.5	16.5	18	17	19.4	51
2. North Group-Birth Year 1961-71	14	27	136	29	19	9	15	17	11.5	13	9.5	14	14	15.2	75
" " " " 1941-60	19	38	124	35.5	22.5	17.5	15	15	12.5	19	13	15	12	18.3	54
" " " " 1931-40	14	19	92	28	23	17	12	20	10.5	15.5	14.5	14.5	13	17.3	43
" " " Prior to 1931	15	26	253	30	26	22	12.5	16	17	16.5	15.5	19	15	18.6	50
3. South Group-Birth Year 1961-71	7	9	46	19.5	22	13	18	14	8	13	16.5	27	19	16.9	35
" " " " 1941-60	12	30	108	18.5	16	18	17.5	14	13	13.5	15	13	-	15.5	70
" " " " 1931-40	8	9	88	24.5	25	17	17	15.5	18.5	16	16.5	10	15	17.2	60
" " " Prior to 1931	12	17	92	26.5	15	22	22.5	21	13	24	18	15.5	20	19.6	51
4. Maximum Value Observed for Year — North Group				75	48	39	27	36	30	40	33	30	22		
South Group				70	42	56	35	44	27	38	29	30	33		

Table 2. Offsite human surveillance program whole-body counting results for ^{137}Cs mean values, ^{137}Cs pCi/kg of body weight. (All values <5 pCi/kg set equal to 5 for determining averages)

For <5 Values Assumed to be 5	Number Families	Number Individuals	Number Counts	Mean pCi/kg for Year and Group Designated										Mean All Years	Maximum Value
				1971	1972	1973	1974	1975	1976	1977	1978	1979	1980		
1. All persons	41	175	1,095	25	19.5	17	13.5	14	12.5	14	14	14.5	13	15.7	75
North Group	27	110	732	27	20	17.5	11.5	14.5	12.5	12.5	13	15.5	13	15.8	75
South Group	14	65	363	20	16	16	15.5	13.5	14	17	15.5	13.5	16	15.7	70
Birth Year 1961-71	21	36	262	29	14.5	10	10.5	11	8	10.5	10	11.5	13	12.3	75
" " 1941-60	31	68	255	28.5	19.5	15.5	14.5	10.5	10	18.5	12.5	14	12	16.3	70
" " 1931-40	22	28	206	37.5	23.5	16	16	16	13	15	16	11.5	14	18.1	60
" Prior to 1931	27	43	372	27.5	23	21.5	14.5	15.5	15.5	17.5	16.5	18	14	18.6	51
2. North Group-Birth Year 1961-71	14	27	207	27	13.5	9.5	7	11.5	8.5	9.5	8	11.5	12	11.7	75
" " " " 1941-60	19	38	131	34	21	17	14	14	10.5	19	13	15	12	16.5	54
" " " " 1931-40	14	19	120	28	23	17	12	18.5	10.5	13.5	14.5	14.5	13	16.0	43
" " " Prior to 1931	15	26	274	28.5	26	22	13	14	16.5	15.5	15.5	19	13	18.6	50
3. South Group-Birth Year 1961-71	7	9	55	12.5	18	11	14	9.5	8	13	15	16	19	11.4	35
" " " " 1941-60	12	30	124	17.5	15.5	18	14.5	12	11	13.5	12.5	13	-	14.2	70
" " " " 1931-40	8	9	86	24.5	25	17	17	14.5	18.5	16	16.5	14.5	15	17.1	60
" " " Prior to 1931	12	17	98	26	15	22	16.5	19	13	22	17	14.5	15	18.5	51
4. Maximum Value Observed for Year	North Group			75	48	39	27	36	30	40	33	30	22		
	South Group			70	42	56	35	44	27	38	29	30	33		
5. Adult males			420	24	20	19	12	13	12	15	14	13	13	15.5	
6. Adult females*			339	21	18	18	12	15	13	13	13	16	16	15.5	

* Born prior to 1940

Table 3. Offsite human surveillance program number of counts performed by age and geographical groupings

Group	Number of Counts for Year and Group Designated										Total Participants
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
1. North Group											
Birth Year 1961-71	16	12	12	15	16	23	28	16	20	11	27
" " 1941-60	45	37	13	9	10	5	4	2	4	2	38
" " 1931-40	28	16	4	7	11	11	15	13	12	6	19
" Prior to 1931	38	23	27	21	25	32	14	28	12	27	25
North Group Total	147	108	56	52	64	71	61	59	68	50	110
2. South Group											
Birth Year 1961-71	11	5	4	6	6	3	6	6	3	2	9
" " 1941-60	30	15	16	17	17	7	7	9	3	-	30
" " 1931-40	11	3	6	6	11	7	13	12	12	9	9
" Prior to 1931	16	9	8	7	13	8	12	11	9	11	17
South Group total	68	32	36	40	47	25	40	38	25	22	65
3. Total North and South Groups	215	140	92	92	111	96	101	97	93	72	175
4. Number of Families Participating	35	25	21	19	20	23	20	17	19	16	41
Number of Family Visits	51	37	27	24	29	32	37	32	34	29	332
5. Number of Adult Males counted*	79	52	44	44	41	39	34	33	37	37	420
Number of Adult Females counted*	71	43	35	30	31	30	30	26	26	17	339
6. Number of Persons for Table 4 Data											
North Group	34	16	29	31	33	36	39	35	38	30	
South Group	12	5	13	13	16	14	16	16	11	11	

* Born prior to 1940; total column is number of counts.

families gives information on the same groups of persons examined over a long period of time. The results are very similar to those in Tables 1 and 2, which are data for all the persons participating in the study.

No striking differences are apparent between the data for the north and south sectors. The trend was for the ^{137}Cs concentration to be higher in older persons than in younger. Because the biological half-life for ^{137}Cs is on the order of months, the relatively constant ^{137}Cs levels in these persons since about 1974 indicate a continuous uptake of this radionuclide, perhaps from delayed fallout or recycling of ^{137}Cs in the food supply (Le76, ICRP71). This relatively constant ^{137}CS level in people has been reported by others, although many organizations have stopped detailed studies of specific population groups (Ma70, Sh73, Gu69, Le76, Th79). These authors reported that in 1964 the ^{137}Cs levels reached a peak of 100–250 pCi/kg for persons in the USA. They correlated this peak with atmospheric tests of nuclear weapons by the USSR and the USA which were conducted in mid-to-late 1962. All authors have shown a rapid decline in the ^{137}Cs body burdens since the 1964 peak. This decline reached averages of 30–60 pCi/kg as a general plateau during 1969–1972, and then decreased to 15–20 pCi/kg by 1975–1976. Similar values and patterns have been measured in beef cattle and wild animals on and around the Nevada Test Site (Sm81).

The results of our ^{137}Cs measurements on the population living around the Nevada Test Site are summarized in Fig. 3. Our annual mean for all persons (data points connected by lines) is somewhat less than that reported by the above authers. However, persons of all ages and both sexes were included in our measurements while most other studies were performed with adult male workers. Our measurements indicate that children tend to have lower ^{137}Cs body burdens than adult males from the same families and/or population. This may be associated with the percentage of muscle tissue per unit of body weight, which tends to be higher for adult males than for children. Cesium, like its chemical analogue potassium, is found predominantly in muscle tissues.

The seasonal (spring and fall) mean concentrations for the north and south sectors are also shown in Fig. 3 along with the maximum values observed in any person during the spring and fall counts. There is no clear difference between the north and south sec-

Table 4. Offsite human surveillance program whole-body counting results for ^{137}C mean values, ^{137}Cs in pCi/kg of body weight for persons counted more than ten times (all values < 5 pCi/kg set equal to 5 for determining averages)

For <5 Values Assumed to be 5	Number Families	Number Individuals	Mean pCi/kg for Year and Group Designated										Mean All Years
			1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
1. All persons	19	56	24	20	17	12	14	13	14	14	15	10	15.3
North Group	13	40	26	21	19	12	14	13	13	12	15	10	15.5
South Group	6	16	16	16	14	13	14	13	16	16	13	11	14.2
Birth Year 1961-71	9	15	20	9	10	9	12	8	10	10	11	10	10.9
" " 1941-60	3	4	22	18	18	12	12	11	18	12	16	12	15.1
" " 1931-40	10	14	24	22	14	14	16	12	14	15	12	9	15.2
" Prior to 1931	13	23	25	23	20	14	16	16	20	17	17	11	17.9
2. North Group-Birth Year 1961-71	6	12	26	13	8	7	11	9	9	9	12	10	11.4
" " " " 1941-60	1	2	29	27	21	16	16	13	19	13	16	12	18.2
" " " " 1931-40	5	8	30	22	14	13	20	10	11	12	13	8	15.3
" " " Prior to 1931	10	18	24	26	23	13	14	17	16	14	18	10	17.5
3. South Group-Birth Year 1961-71	3	3	13	5	12	11	14	8	12	11	10	10	10.6
" " " " 1941-60	3	4	15	10	14	7	9	8	15	11	-	-	11.2
" " " " 1931-40	5	6	18	24	14	15	12	14	16	18	12	10	15.3
" " " Prior to 1931	3	5	16	20	17	15	18	15	24	19	15	12	17.1

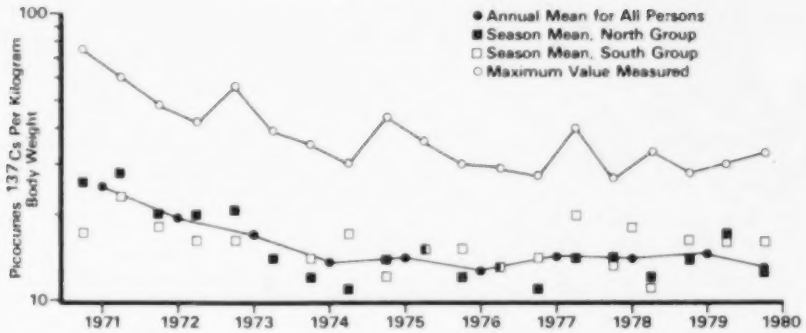

FIG. 3. Mean and maximum concentrations of ^{137}Cs for residents participating in the offsite human surveillance program.

tors or between the spring and fall counts. The maximum values were not clearly associated with any particular person or group. The 2σ counting errors at 15 pCi/kg of ^{137}Cs are approx. ±75%; therefore, fluctuations around the average line by north–south and spring-fall data are not large enough to be significant.

In the urine samples analyzed for family groups, no ^{238}Pu or ^{239}Pu was found. Tritium concentrations in urine generally were within the range of background concentrations normally observed by the EMSL–LV in surface waters or atmospheric moisture. The minimum detectable level for tritium in urine was about 300 pCi/l. For the plutoniums, the minimum detectable levels were about 0.04 pCi/l and 0.08 pCi/l for ^{238}Pu and ^{239}Pu, respectively (Po80). These detectable levels were somewhat variable, depending on the volume of urine in the sample and other activities in the laboratory, e.g. samples associated with NTS Tests. Two of the highest tritium values measured, approx. 10 nCi per liter, were in urine samples from members of the same family; the other members of this family had low values. This variation would seem to rule out a contaminated water or food source. Subsequent investigation of these levels revealed leaking tritium-dial watches worn by the family members who had the high values of tritium in urine.

The ^{137}Cs results from whole-body counting can be assessed in terms of an accumulated radiation dose (Re68). If a level of 100 pCi/kg is maintained in a 70 kg person for 1 yr, the accumulated total body dose to that person would be 0.8 mrad. For a 25 kg child, the 100 pCi/kg concentration would result in a dose approx. 10% lower because of greater escape of radiation from the body before absorption. On this basis and for the average concentrations of ^{137}Cs from Table 2 (less than 5 pCi/kg values included), the annual radiation dose to a 70 kg person would range from 0.2 mrad in 1971 to 0.1 mrad in 1980. The possible annual dose from the maximum concentration found in an individual would be 0.6 mrad in 1971.

One family living near Beatty, Nevada, was selected because of known ^{131}I contamination of their milk supply due to the Baneberry test in December 1970. The family was counted several weeks after the event and two members had trace amounts (300 pCi and 150 pCi) of the nuclide in their thyroid glands. The estimated doses were 7 and 6 mrad, respectively; the second individual was a young person with a smaller thyroid than the first.

Two adult males participating in the survey had burdens of fission products other than ^{137}Cs. One individual worked at a nuclear waste disposal site and had a 3.4 nCi ^{60}Co burden. The other individual worked as a monitor at the Nevada Test Site and had a 1.5 nCi ^{103}Ru burden at the time of the count.

Medical examinations revealed the health

of this group as not much different than the general population. During this period of time, we have had no deaths, but have found many of the infirmities occurring in an aging population. A significant number of individuals were over 70 years of age, the oldest being 80 yr of age. The youngest was 4 yr old in 1970.

The diseases noted have been—

1. The arthritics.
2. Hypertension.
3. Cardiac decompensation.
4. Two colloid type goitres which were found on initial examination in 1970. No changes have been noted in the past 10 yr. The thyroid profile results have all been within the normal range.
5. One diabetic (80 yr old).
6. Enlarged prostate—he has had a TUR (Trans-urethal resection).
7. Several exposed-area skin cancers common in the desert.

Of the original 41 families and 175 individuals, 18 families and 47 individuals have remained with this continuing monitoring program. Many families have moved from the locality, and many of the original children and teenagers have started families in other areas. As families or family members moved out of the area, they were dropped from the program and not replaced.

In conclusion, ^{137}Cs is the major fission product normally found in this off-site population. The cesium concentration in these people living close to the Nevada Test Site is similar to that in people living elsewhere in the United States. Continuing global fallout from upper atmospheric reservoirs and residuals from previous depositions are probably the source for levels currently found in people. No clear difference was found between persons living on the windward and leeward sides of the Nevada Test Site. The population has been generally healthy and has had the normal problems associated with aging and exposed-area skin cancers common in the desert.

NOTICE

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